

**TEST PLAN FOR THE VACUUM TEST OF THE  
O-RING TEST FIXTURE (OTF) FOR THE  
ALPHA MAGNETIC SPECTROMETER (AMS)-02**

**TWP MHECSMBSX**

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Lyndon B. Johnson Space Center**

July 18, 2002

## Test Plan for the O-Ring Test Fixture

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**ACRONYMS AND ABBREVIATIONS**

AMS	Alpha Magnetic Spectrometer
FEM	Finite Element Model
JSC	Johnson Space Center
LBB	Leak Before Burst
LMSO	Lockheed Martin Space Operations
MSDS	Material Safety Data Sheet
OTF	O-Ring Test Fixture
P/N	Part Number
QA	Quality Assurance
STL	Structural Testing Laboratory
TPS	Task Preparation Sheet
TRR	Test Readiness Review

## 1. Test Objectives

- 1.1. The vacuum test will verify that the current O-Ring groove configuration will seal at  $1 \times 10^{-6}$  torr.
- 1.2. The vacuum test will determine the short term and long term leak rate of the OTF.
- 1.3. The vacuum test will verify procedures used for O-Ring seal integrity on the OTF are adequate. The same procedures will be used on the Flight Vacuum Case.
- 1.4. Yielding of the OTF is not expected at a vacuum of  $1 \times 10^{-6}$  torr. Pretest analysis has been performed and is attached as Appendix A of this document.
- 1.5. The vacuum test will verify that the iridizing process will not outgas when applied to the internal surfaces of the OTF.
- 1.6. Strain and deflection data will be taken during the first test. This data will be used to verify the FEM of the OTF.

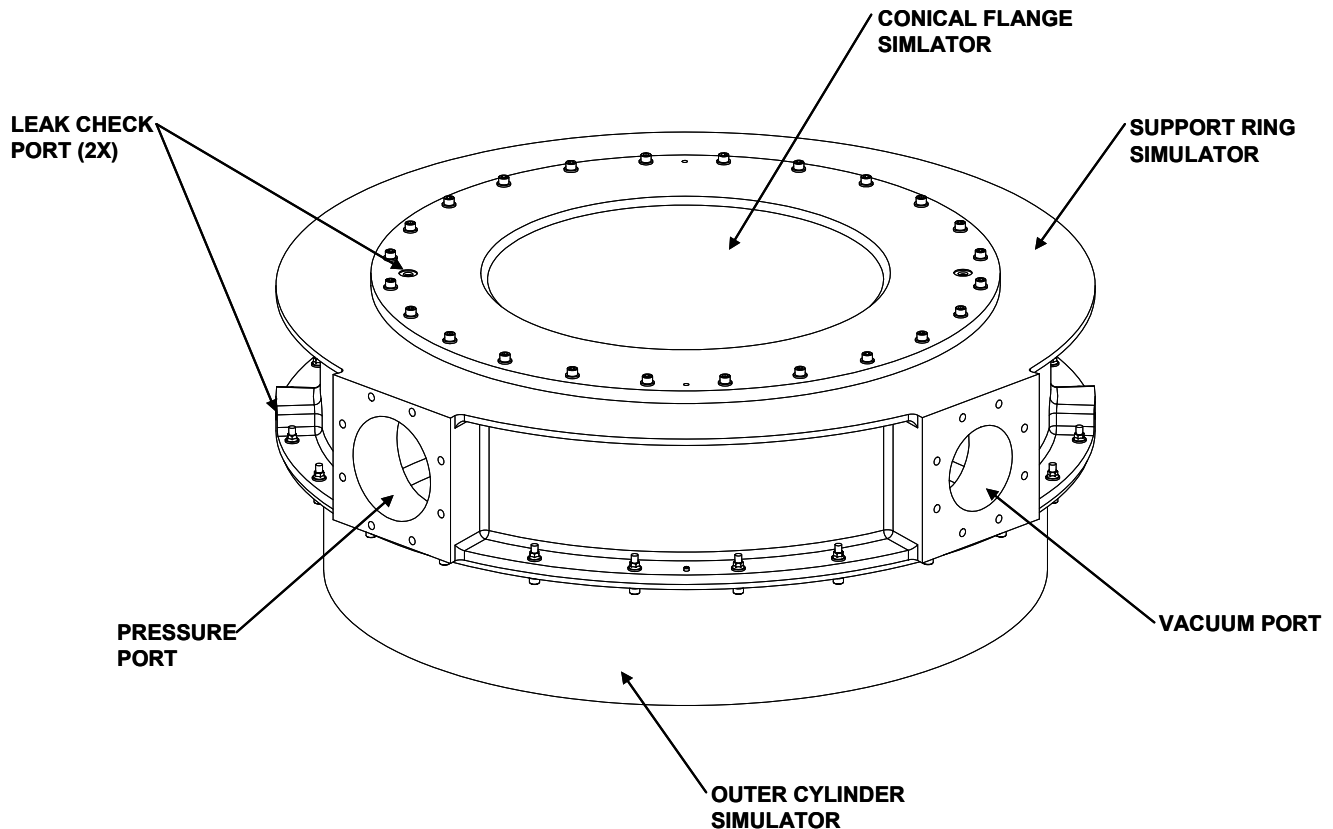
## 2. Test Overview

The vacuum test of the OTF will consist of five individual test cases. The first test case will determine if the OTF can reach the required vacuum level ( $1 \times 10^{-6}$  torr) in the as built configuration. There are several scratches across the main o-ring grooves due to previous improper handling for the positive pressure test and performing this test will help determine how much groove damage can be tolerated before repair is necessary. Strain and deflection data will also be collected during this test for FEM verification. A hard vacuum of  $1 \times 10^{-6}$  torr is not required for the data collection as long as a vacuum is achieved. A vacuum of approximately  $1 \times 10^{-2}$  torr is sufficient but the Test Engineer will make a final determination during the test. If the required vacuum can be reached, then the OTF will proceed to test case 2. If the required vacuum cannot be reached, then the OTF will need to be repaired. After the repairs, the first test case will be repeated to insure that the required vacuum of  $1 \times 10^{-6}$  torr can be reached. The second test case will consist of leak checks on both the individual O-Rings and the system. This test case will leak check all the large O-rings using a helium leak detector. This test will also determine the leak rate of the OTF. The third test case, which is similar to the first, will determine if the OTF will experience any outgassing problems due to the iridite process. An outside vendor will perform the iridite process and the time frame between test case 2 and 3

will be about one month. The fourth test case will consist of leak checks on both the individual O-Rings and the system as in test case 2. This test will also determine the leak rate of the OTF with the iridited internal surfaces. Test case 5 will be a long-term vacuum test. The OTF will be sealed and set aside. Pressure will be checked on a daily basis for the first few weeks and then on a weekly basis to determine long-term leak rates.

### 3. Test Article

The test article consists of one Class III OTF, P/N SEG36144341-301, and is shown in Figure 3-1.

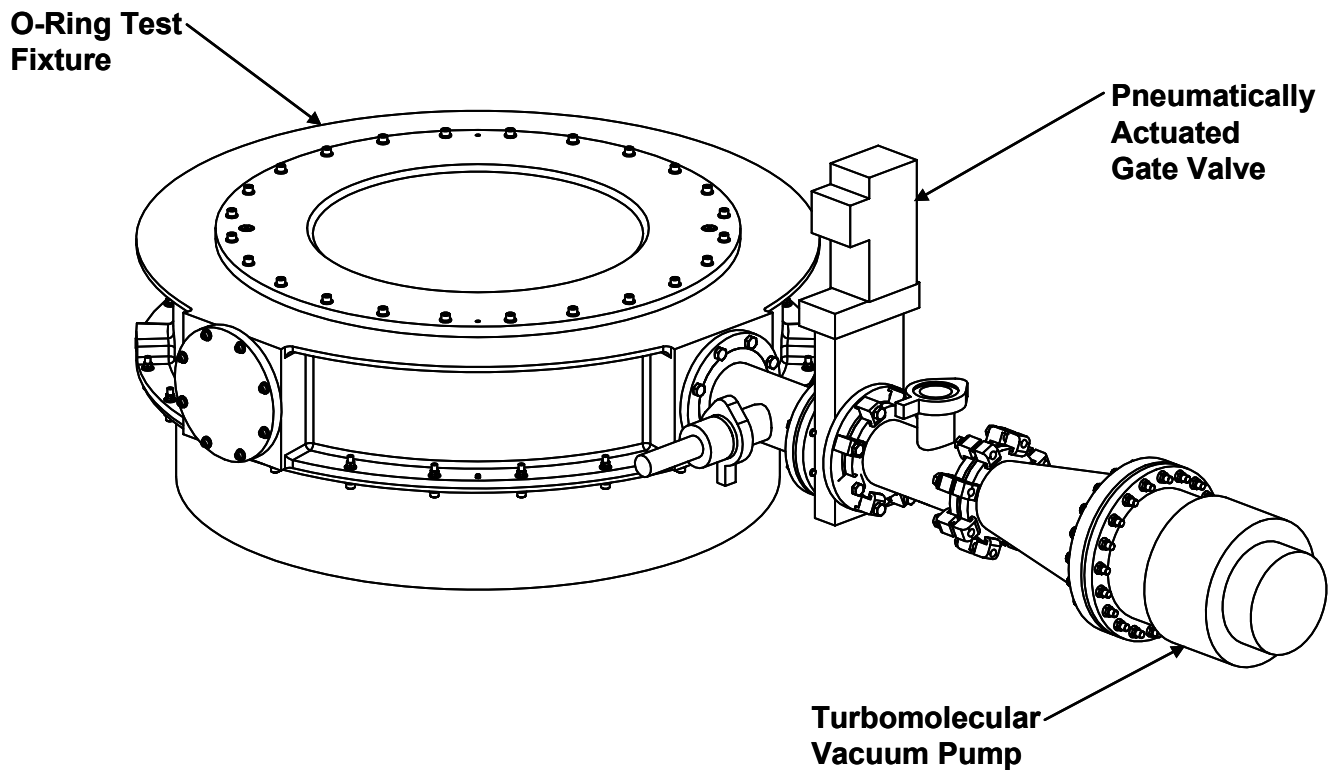


**Figure 3-1: O-Ring Test Fixture (OTF)**



## 4. O-Ring Tests

Figure 4-1 shows the generic test setup for the OTF with the pneumatically actuated gate valve and turbomolecular vacuum pump.



**Figure 4-1: Vacuum Test Hardware**

### 4.1. Test Case I (Vacuum Pull As Built and Data Collection)

- 4.1.1. Disassemble OTF per Appendix B.
- 4.1.2. Remove OXSOL-100 protective coating on the Conical Flange by hand only. The personnel removing the coating must wear lint-free latex gloves. Clean the area that the OXSOL-100 protected with Isopropyl Alcohol, Reagent Grade, along with lint free cloths to remove any coating residue.
- 4.1.3. Assemble the OTF per Appendix C.
- 4.1.4. Place the assembled OTF on the support frame supplied by the AMS project. The frame will support the entire

circumference of the Outer Cylinder Simulator while allowing the OTF to deflect without affecting the results.

- 4.1.5. Assemble vacuum hardware per Appendix D.
- 4.1.6. Connect gages and setup data acquisition system per section 4.
- 4.1.7. Perform test per TPS. (Procedures overview can be found in Appendix J)
- 4.1.8. Disassemble OTF or continue Test per AMS-02 test engineer's instruction.

## **4.2. Test Case II (O-Ring Leak Check)**

- 4.2.1. If OTF was disassembled in 4.1.8, assemble OTF per Appendix C.
- 4.2.2. Reconfigure hardware for Conical Flange external O-Ring leak check per Appendix E.
- 4.2.3. Perform leak check per TPS. (Procedures overview can be found in Appendix K)
- 4.2.4. Reconfigure hardware for Support Ring external O-Ring leak check per Appendix F.
- 4.2.5. Perform leak check per TPS. (Procedures overview can be found in Appendix K)
- 4.2.6. Reconfigure hardware for Conical Flange internal O-Ring leak check per Appendix G.
- 4.2.7. Perform leak check per TPS. (Procedures overview can be found in Appendix L)
- 4.2.8. Reconfigure hardware for Support Ring internal O-Ring leak check per Appendix H.
- 4.2.9. Perform leak check per TPS. (Procedures overview can be found in Appendix L)
- 4.2.10. Reconfigure hardware for system leak check per Appendix I.

4.2.11. Perform leak check per TPS. (Procedures overview can be found in Appendix M)

4.2.12. Disassemble OTF or continue Test per AMS-02 test engineer's instruction.

#### **4.3. Test Case III (Vacuum Pull after Iridite)**

4.3.1. IF OTF was disassembled, assemble OTF per Appendix C.

4.3.2. The OTF will be supported around the entire circumference of the Outer Cylinder Simulator by a wood frame. This will allow the OTF to deflect without affecting the results.

4.3.3. Setup vacuum hardware per Appendix D.

4.3.4. Perform test per TPS. (Procedures overview can be found in Appendix J)

#### **4.4. Test Case IV (O-Ring Leak Check)**

4.4.1. If OTF did not reach  $1 \times 10^{-6}$  torr in Section 4.3 perform leak checks per section 4.2

#### **4.5. Test Case V (Long Term Leak Rate)**

4.5.1. Perform test per TPS. (Procedures overview can be found in Appendix N)

## **5. Test Instrumentation**

### **5.1. Gages**

The OTF will require the following instrumentation (see Table 5.1-1 for a list of gages):

- 11 Deflection gages
- 4 Triaxial Strain gages
- 1 Uniaxial gage
- 1 Pressure gauge

The strain gages have already been installed for the positive pressure test and only need to be connected. Building 33 personal my use building 13 personal for any or all gage setups. This instrumentation will only be needed on Test Case 1 (Section 4.1).

**Table 5.1-1 Summary of Strain and Deflection Gages**

Location	Description	Type	Qty	Gage #	Channels
Conical Flange	Between O-Ring grooves on outer surface	Deflection	1	1	1
Conical Flange	Outer diameter of flange	Deflection	1	2	1
Support Ring	Center of upper surface	Deflection	1	3	1
Support Ring	Upper surface directly above ring web	Deflection	1	4	1
Support Ring	Between O-Ring grooves on outer surface	Deflection	1	5	1
Support Ring	Outer diameter at cylinder interface	Deflection	1	6	1
Outer Cylinder	Outer diameter of cylinder	Deflection	1	7	1
Outer Cylinder	Outer surface between O-Ring grooves on ring	Deflection	1	8	1
Conical Flange	Center of flange	Deflection	1	9	1
Outer Cylinder	Center of bottom surface	Deflection	1	10	1
Support Ring	Center of vertical cross section	Deflection	1	11	1
Conical Flange	Center of flange	Triaxial	1	A	3
Support Ring	Lower surface next to bolt	Triaxial	1	B	3
Outer Cylinder	Outside surface across from inside radius	Triaxial	1	C	3
Conical Flange	Outer surface next to fastener	Uniaxial	1	E	1
Support Ring	Center of vertical cross section	Triaxial	1	G	3
Support Ring	Interface Flange of pressure port	Transducer	1	N/a	1
		<b>Total</b>	<b>17</b>	<b>-</b>	<b>25</b>

## 5.2. Strain Gage Setup

For strain gage setup, use material properties shown in Table 5.2-1. Gages shall be labeled as shown in Table 5.1-1.

**Table 5.2-1 Material Properties for Strain Gage Setup**

Location	Material	E x 10 <sup>6</sup> psi		ν
		Tension	Compression	
Conical Flange	Aluminum 2219-T851 Plate	10.5	10.8	.33
Support Ring	Aluminum 7050-T7451 Plate	10.3	10.6	.33
Outer Cylinder	Aluminum 7050-T7451 Plate	10.3	10.6	.33

## 5.3. Deflection Gage Setup

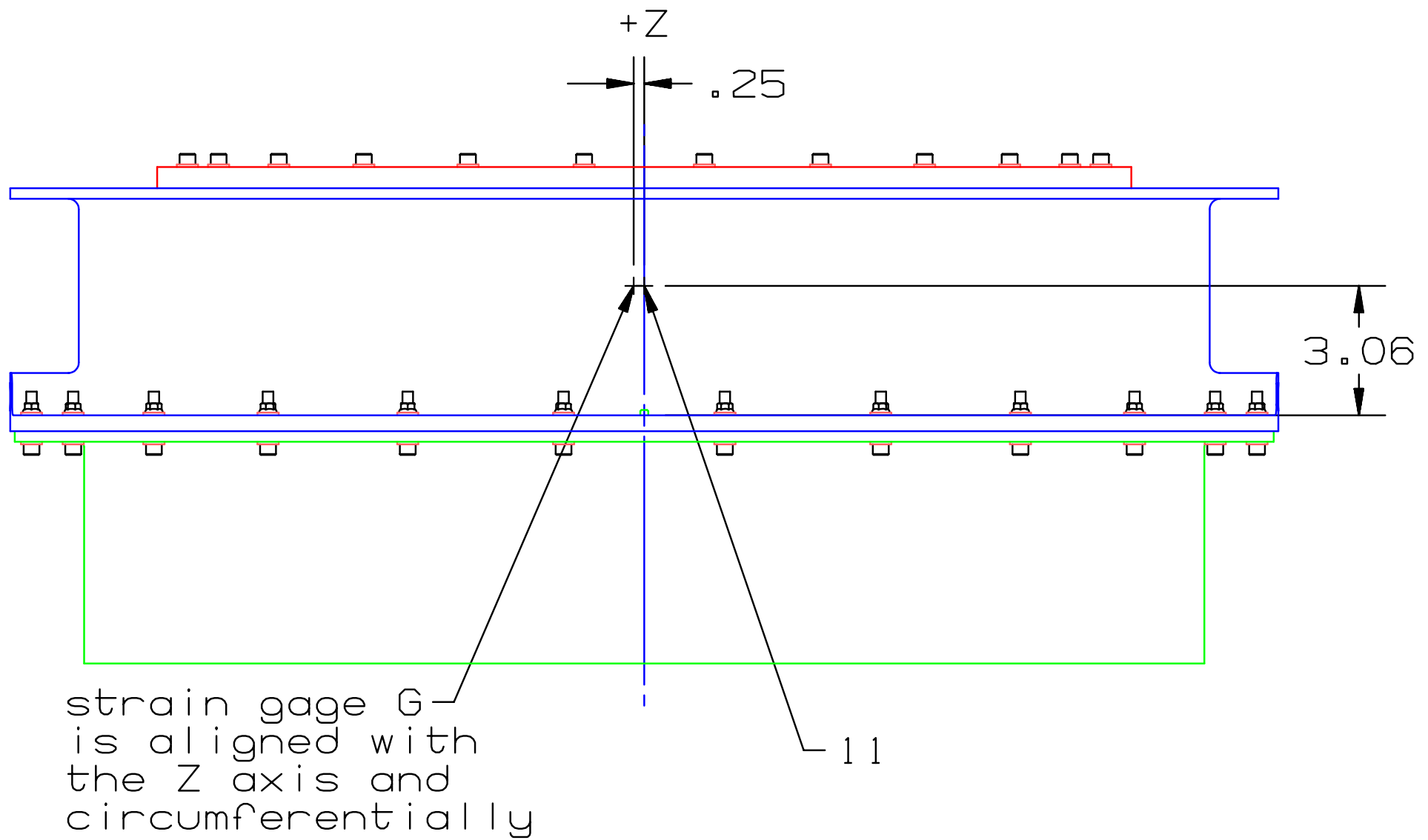
Each gage should be clearly labeled with the gage number. See Table 5.3-1 for a list of the deflection gages. The expected deflection is expected to be very small for most of the gages with the exception of two; gage 9 and gage 10. Gages 9 & 10 will deflect inward towards the center of the OTF.

**Table 5.3-1 Deflection Gage Summary**

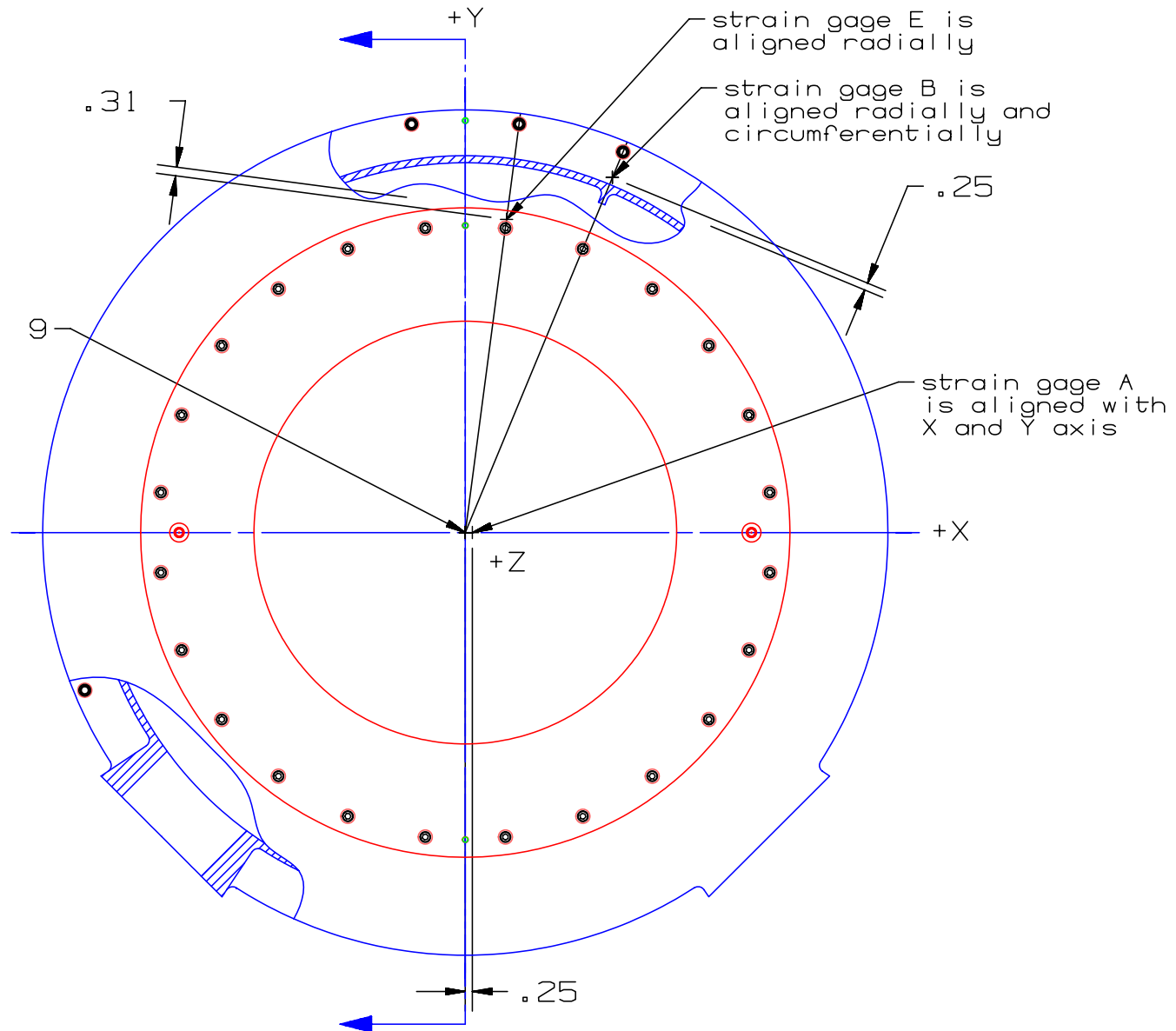
Location	Description	Gage #	Axis	Expected Deflection
Conical Flange	Between O-Ring grooves on outer surface	1	Z	< 0.1
Conical Flange	Outer diameter of flange	2	Z	< 0.1
Support Ring	Center of upper surface	3	Z	< 0.1
Support Ring	Upper surface directly above ring web	4	Z	< 0.1
Support Ring	Between O-Ring grooves on outer surface	5	Z	< 0.1
Support Ring	Outer diameter at cylinder interface	6	Z	< 0.1
Outer Cylinder	Outer diameter of cylinder	7	Z	< 0.1
Outer Cylinder	Outer surface between O-Ring grooves on ring	8	Z	< 0.1
Conical Flange	Center of flange	9	Z	~ 0.38
Outer Cylinder	Center of bottom surface	10	Z	~ 0.38
Support Ring	Center of vertical cross section	11	Radial	

#### **5.4. Gage Configuration**

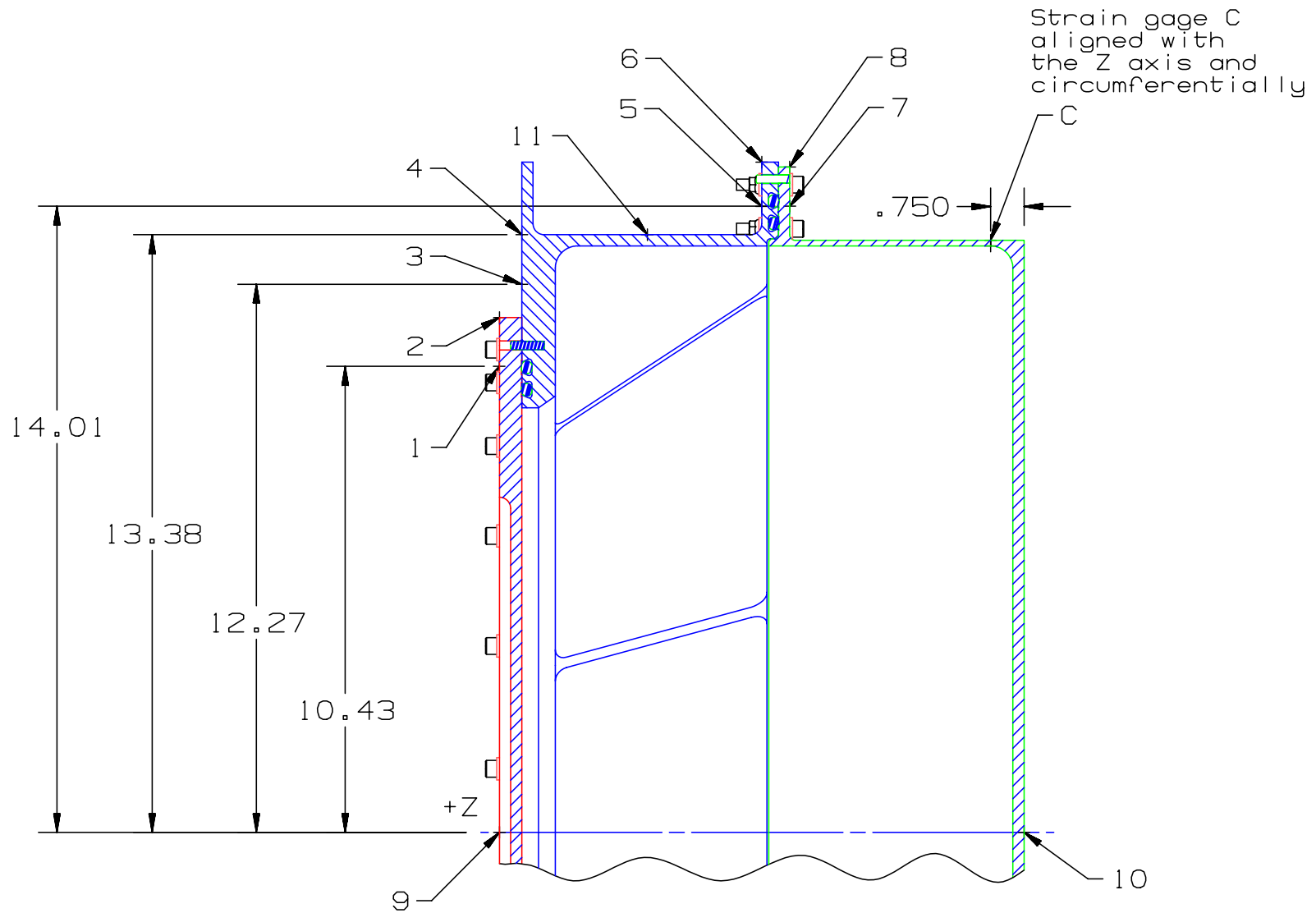
Configure gages per Figures 5.4-1 - 5.4-3. Relocation of some gages might be necessary due to the distance between the edge of the test article and the sensors. Relocation will only be necessary if a gage has been damaged during transportation and setup. STL and AMS personnel will need to agree upon the placement of the relocated sensors for practicality of the location and usefulness of the data that will be collected.

**Figure 5.4-1: Gage Setup, Front View**





**Figure 5.4-2: Gage Setup, Top View**

**Figure 5.4-3: Gage Setup, Section View**

## **6. Pass/Fail Criteria**

This is an engineering evaluation test to determine the leak rate of the OTF system. If the OTF system cannot reach a vacuum of  $1 \times 10^{-6}$  torr, the hardware will be modified in order to improve the sealing capabilities of the O-rings.

## 7. Test Support, OTF

This test will be used for FEM verification and leak rate determination. Full Quality Assurance (Q.A.) coverage is required. The OTF review board will determine test readiness and approve continuation of the test/procedures. Table 7-1 defines the members of the review board. Others may be added as needed.

**Table 7-1. OTF Review Board**

<b>Responsibility</b>	<b>Representative</b>	<b>Contact</b>
OTF Test Engineer	Hsing Ju / LMSO	281-333-7494
AMS-02 Test Lead Engineer	Phil Mott / LMSO	281-333-6451
CTSD Lead Engineer	Jenny Andrews	281-483-6948
CTSD Engineer	Matt Blackmer	281-483-2831
Project Manager	Kenneth Bollweg / LMSO	281-335-2714
Structural Lead	Trent Martin / LMSO	281-335-2139
Stress Lead	Chittur Balasubramanian / LMSO	281-333-7518
Stress Analyst	Howard Carter / LMSO	281-333-7339
Safety	Doug Harris / USA / B33	281-483-7101
Q.E.	Albert Ruder / WGI / B33	281-483-4997
Facility Personnel	James Hampton / LMSO / B33	281-483-9184
Chairperson	Reagan Redman / NASA / 7A	281-483-9213

## Appendix A: OTF Disassembly Procedure

**Note: Unless otherwise specified, personnel working on the disassembly of the OTF should wear lint free latex gloves to minimize contamination of the interfaces.**

1. Remove flanges, P/N SDG36144345-001 and –005, from the OTF. Place the flanges, P/N SDG36144345-001 and –005, into separate plastic bags. Place the bolts into another set of plastic bags. Remove the O-Ring in the O-Ring grooves of the flanges and place them into separate plastic bags to prevent contamination.
2. Remove the Conical Flange Simulator, P/N SDG36144342-001, from the Support Ring Simulator, P/N SEG36144343-301. Place the Conical Flange Simulator, P/N SDG36144342-001, with the O-Ring grooves facing up to the side. The personnel should wear lint free glove to prevent contamination of the internal surface of the OTF, P/N SEG36144341-301. Seal the O-Ring grooves on the Conical Flange Simulator, P/N SDG36144342-001, with Kapton tape after removal to minimize contamination and damage. Place the bolts into another set of plastic bag.
3. Remove O-Rings SLG36144346-001 and –003 from the dovetail O-Ring grooves and place the O-Rings into a plastic bag to prevent contamination. Do not damage the surface of the O-Ring grooves when removing the O-Rings. Seal O-Ring grooves on the Support Ring Simulator assembly, P/N SEG36144343-301, with Kapton tape after O-Ring removal to minimize contamination and damage.
4. Remove the strain gage and associated wires that are located inside the outer cylinder, P/N SEG36144344-301. The personnel should wear lint free gloves to prevent contamination of the internal surface of the Outer Cylinder, P/N SEG36144344-301.
5. After the removal of the internal strain gage, clean the contact area of the strain gage using Isopropyl Alcohol, Reagent Grade, with lint free cloth to remove strain gage adhesive. Wipe the surface clean with lint free cloth and clean up any spills that are inside the OTF.
6. Remove Support Ring Simulator, P/N SEG36144343-301, from the Outer Cylinder Simulator, P/N SEG36144344-301. Place the bolts and nuts into a plastic bag. Place the Support Ring Simulator, P/N SEG36144343-301, on a clean sheet of paper with the O-Ring grooves that mate with the Outer Cylinder, P/N SEG36144344-301, facing up.
7. Remove O-Rings SLG36144346-005 and –007 from the dovetail O-Ring groove and place the O-Rings into a plastic bag to prevent contamination. Seal O-Ring groove with Kapton tape after O-Ring removal to prevent contamination.
8. Seal the mating surface on the Outer Cylinder Simulator, P/N SEG36144344-301, with Kapton tape to minimize contamination and damage.

## **Appendix B: Stress Analysis**

## Appendix C: OTF Assembly Procedure

**Note:** Unless otherwise specified, personnel working on the disassembly of the OTF should wear lint free latex gloves to minimize contamination of the interfaces.

1. Remove Kapton tape from the mating surface of the Support Ring Simulator assembly, P/N SEG36144343-301, and the Outer Cylinder Simulator assembly, P/N SEG36144344-301. Clean the mating surface of the Outer Cylinder Simulator assembly with Isopropyl Alcohol, Reagent Grade, to remove any corrosion, tape adhesive, and vacuum grease. Also clean the exposed O-Ring grooves of the Support Ring Simulator assembly, P/N SEG36144343-301, with Isopropyl Alcohol, Reagent Grade, to remove any corrosion, tape adhesive, and vacuum grease.
2. Wearing lint free gloves, remove 1 O-Ring, P/N SLG36144346-005, from the pouch and apply a thin coat of High Vacuum Grease, P/N 1597418, to the O-Ring by squeezing some of the grease from the tube into the palm of the glove and pulling the O-Ring through the grease. The grease should evenly coat the O-Ring. Make sure that the O-Ring does not come in contact with other surfaces during the application of High Vacuum Grease. After the application of the High Vacuum Grease, place O-Ring into the smaller O-Ring groove on the Support Ring Simulator assembly, P/N SEG36144343-301.
3. Repeat the previous step except remove 1 O-Ring, P/N SLG144346-007, from the pouch and install in the larger O-Ring groove of the Support Ring Simulator assembly, P/N SEG36144343-301.
4. Dispose of excess grease and soiled gloves per the Material Safety Data Sheet (MSDS).
5. Carefully wipe off any grease from the surfaces outside of the O-Rings using Isopropyl Alcohol, Reagent Grade, with lint free cloths. The area between the O-Rings should be left alone unless there is a glob of grease on the surface (This will be determined by the test engineer). Do not touch any part of the O-Rings during the cleaning procedure. Clean as close as possible to the O-Rings without touching them.
6. Remove Kapton tape from the mating surface of the Outer Cylinder Simulator assembly, P/N SEG36144344-301. Clean the mating surface of the Outer Cylinder Simulator with Isopropyl Alcohol, Reagent Grade, along with lint free cloth to remove any corrosion, tape adhesive, and vacuum grease.
7. Install the Support Ring Simulator assembly, SEG36144343-301, to the Outer Cylinder Simulator assembly, SEG3614344-301, using 24 .250-28UNRF-3A 1.25-inch long fasteners, P/N NAS1351N4H20 and .250-28UJF-3B nuts, P/N NAS1291C4M. During the installation process, do not slide the O-Ring groove surface on the Support Ring Simulator assembly, P/N SEG36144343-301, across the mating surface of the Outer Cylinder Simulator assembly, SEG36144344-301. Install the nuts and the screws in

- a crisscross pattern to insure even O-Ring compression. Measure and record the running torque for each fastener. Final torque is 65-75 in-lbs above running torque.
8. Remove Kapton tape from the mating surface of the Support Ring Simulator assembly, P/N SEG36144343-301, and the Conical Flange Simulator assembly, P/N SDG36144342-001. Clean the mating surface of the Support Ring Simulator with Isopropyl Alcohol, Reagent Grade, to remove any corrosion, tape adhesive, and vacuum grease. Also clean the exposed O-Ring grooves of the Support Ring Simulator assembly, P/N SEG36144343-301, with Isopropyl Alcohol, Reagent Grade, to remove any corrosion, tape adhesive, and vacuum grease.
  9. Wearing lint free gloves, remove 1 O-Ring, P/N SLG36144346-001, from the pouch and apply a thin coat of High Vacuum Grease, P/N 1597418, to the O-Ring by squeezing some of the grease from the tube into the palm of the glove and pulling the O-Ring through the grease. The grease should evenly coat the O-Ring. Make sure that the O-Ring does not come in contact with other surfaces during the application of High Vacuum Grease. After the application of the High Vacuum Grease, place O-Ring into the smaller O-Ring groove on the Support Ring Simulator assembly, P/N SEG36144343-301.
  10. Repeat the previous step except remove 1 O-Ring, P/N SLG144346-003, from the pouch and install in the larger O-Ring groove of the Support Ring Simulator assembly, P/N SEG36144343-301.
  11. Dispose of excess grease and soiled gloves per the Material Safety Data Sheet (MSDS).
  12. Carefully wipe off any grease from the surfaces outside of the O-Rings using Isopropyl Alcohol, Reagent Grade, with lint free cloths. The area between the O-Rings should be left alone unless there is a glob of grease on the surface (This will be determined by the test engineer). Do not touch any part of the O-Rings during the cleaning procedure. Clean as close as possible to the O-Rings without touching them.
  13. Remove Kapton tape from the mating surface of the Conical Flange Simulator, P/N SDG36144342-001. Clean the mating surface of the Conical Flange Simulator with Isopropyl Alcohol, Reagent Grade, to remove corrosion, tape adhesive, and vacuum grease.
  14. Install the Conical Flange Simulator, P/N SDG36144342-001, to the Support Ring Simulator assembly, P/N SEG3614343, using 24 .250-28UNRF-3A 1-inch long fasteners, P/N NAS1351N4H16. During the installation process, do not slide the O-Ring groove surface on the Conical Flange Simulator, P/N SDG36144342-001, across the mating surface of the Support Ring Simulator assembly, SEG36144343-301. Install the nuts and the screws in a crisscross pattern to insure even O-Ring compression. Measure and record the running torque for each fastener. Final torque is 65-75 in-lbs above running torque
  15. Seal all leak check ports with a hollow hex plug, P/N 2 HP5ON SS V0894. Torque hex plug 30-33 in-lbs from finger tight.



16. Cover open feed thru ports with Kapton tape to minimize contamination of the OTF.

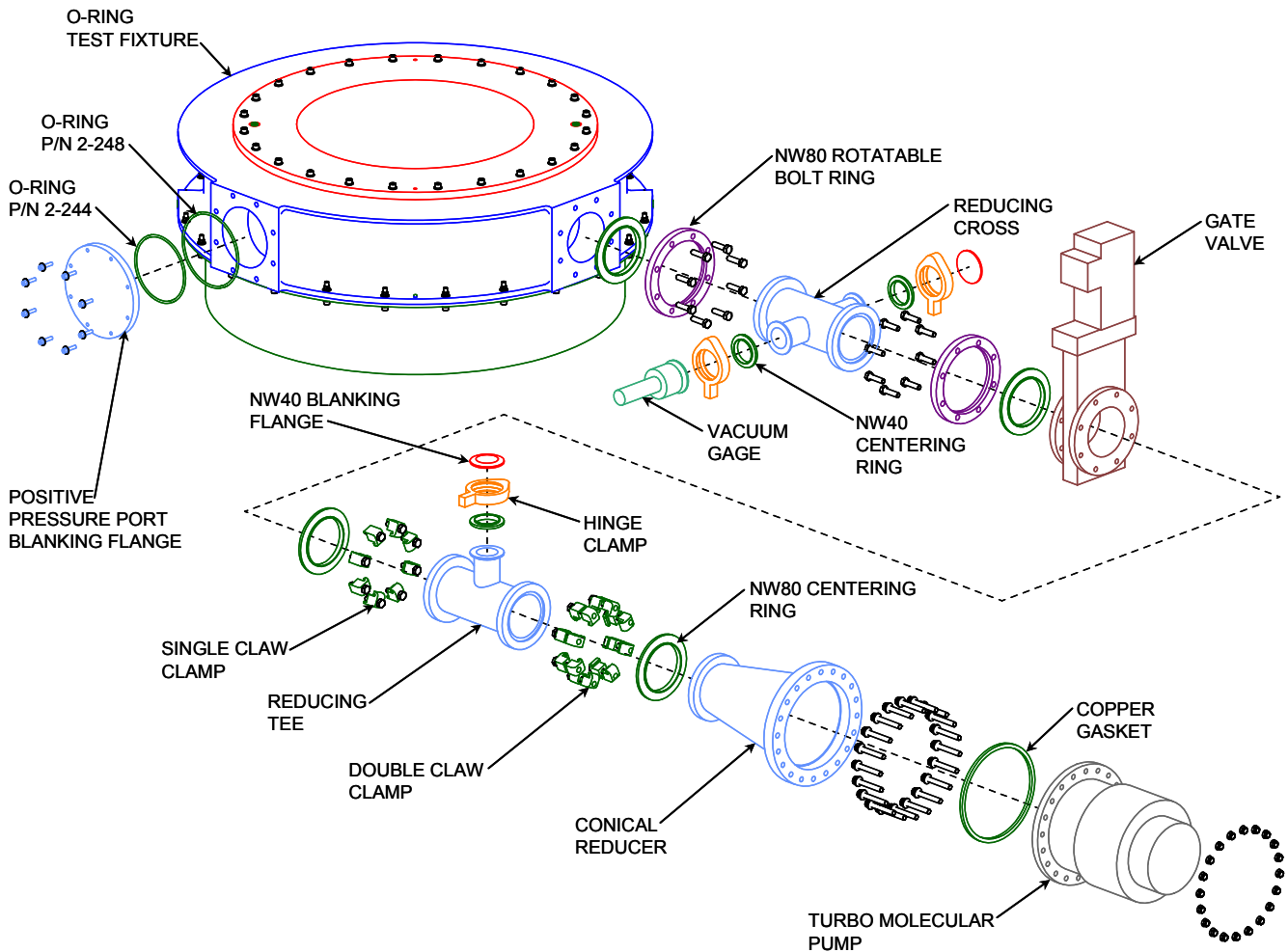
## Appendix D: OTF Vacuum Hardware Assembly Procedure

**Note:** Unless otherwise specified, personnel working on the disassembly of the OTF should wear lint free latex gloves to minimize contamination of the interfaces.

1. Remove the Kapton tape that covers the O-Ring grooves on the Positive Pressure Port Blanking Flange, P/N SDG36144345-003.
2. Remove corrosion, tape adhesive, and grease from the mating surface and O-Ring grooves of the Positive Pressure Port Blanking Flange, P/N SDG36144345-003, with Isopropyl Alcohol, Reagent Grade, by wiping surface with lint free cloth.
3. Wearing lint free gloves, remove 1 O-Ring, P/N 2-244, from the pouch and apply a thin coat of high vacuum grease, P/N 1597418, to the O-Ring by squeezing some of the grease from the tube into the palm of the glove and pulling the O-Ring through the grease. The grease should evenly coat the O-Ring. After the application of the high vacuum grease, place O-Ring into the smaller O-Ring groove on the Positive Pressure Port Blanking Flange, P/N SDG36144345-003.
4. Repeat the previous step except remove 1 O-Ring, P/N 2-248, from the pouch and install in the larger O-Ring groove of Positive Pressure Port Blanking Flange, P/N SDG36144345-003.
5. Dispose of excess grease and soiled gloves per the Material Safety Data Sheet (MSDS)
6. Remove the Kapton tape that covers the surface of the positive pressure port, identified by PSI, on the Support Ring Simulator, P/N SEG36144343-301.
7. Remove corrosion, tape adhesive, and grease from the surface of the positive pressure port, identified by PSI on the interface surface, with Isopropyl Alcohol, Reagent Grade, by wiping surface with lint free cloth. Clean surface by wiping in a circular direction with port as the center. Check the positive pressure port surface on OTF for damage after cleaning. Record any visible damage.
8. Carefully wipe off any grease from the surfaces outside of the O-Rings using Isopropyl Alcohol, Reagent Grade, with lint free cloths. The area between the O-Rings should be left alone unless there is a glob of grease on the surface (This will be determined by the test engineer). Do not touch any part of the O-Rings during the cleaning procedure. Clean as close as possible to the O-Rings without touching them.
9. Seal the positive pressure port, identified by PSI, with the positive pressure port blanking flange, P/N SDG36144345-003, using 10-32UNJF-3B bolts, P/N NAS1351N3H12. Install bolts and torque 25-30 in-lbs. above running/locking torque. Running/locking torque should be 2 to 18 in-lbs. Install the bolts in a crisscross pattern to insure even compression of the O-Rings.

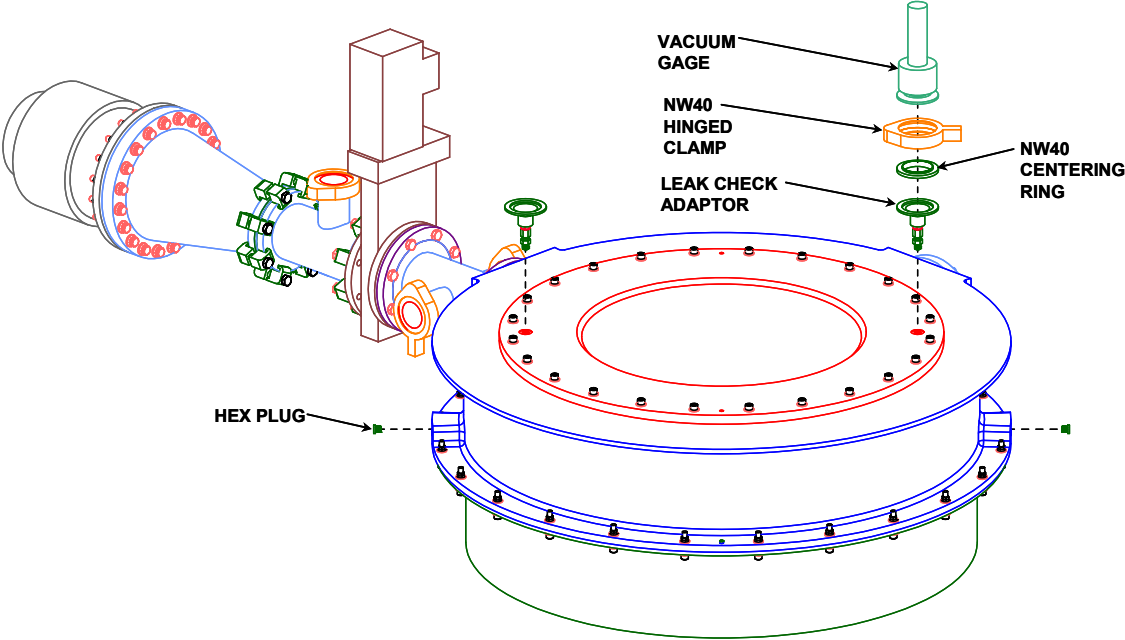
10. Remove the Kapton tape that covers the surface of the vacuum port, identified by VAC, on the Support Ring Simulator, P/N SEG36144343-301.
11. Remove corrosion, tape adhesive, and grease from the mating surface vacuum port with Isopropyl Alcohol, Reagent Grade, by wiping surface with lint free cloth.
12. Install NW80 centering ring, P/N 810008, and NW80 LF to NW40 KF reducing cross, P/N MSPB1260, to the chamber using NW80 rotatable bolt ring, P/N 824043, and 8 M8 X 1.25 X 30L bolts with washer, P/N 854021. Orient the reducing cross so that the cross is parallel to the ground. Net torque is 7 to 10 ft-lbs per manufacturer's recommendation. Running/locking should be 7.5-80 in-lbs. Install the bolts in a crisscross pattern to ensure even compression of the O-Rings.
13. Install the NW80 centering ring, P/N 810008, and electropneumatic gate valve, P/N 307004, to the NW80 LF to NW40 KF reducing cross, P/N MSPB1260, using NW80 rotatable bolt ring, P/N 824043, and 8 M8 X 1.25 X 30L bolts with washer, P/N 854021. Net torque is 7 to 10 ft-lbs per manufacturer's recommendation. Running/locking should be 7.5-80 in-lbs. Install the bolts in a crisscross pattern to ensure even compression of the O-Rings. Support the Gate Valve after assembly to prevent damage to the OTF.
14. Install 1 copper gasket, P/N 191017, and NW80 LF to DN160 CF conical adapter, P/N MSPB1286, to the Leybold AG Turbovac 361 model 85673 provided by the B33 Test Facility using 20 .312-24 x 2.9L 12 point bolt w/ washer, P/N 190045. Net torque is 15 ft-lbs per manufacturer's recommendation. Running/locking should be 7.5-80 in-lbs. Install the bolts in ¼ to ½ turn increments in a crisscross pattern to ensure even compression of the copper gasket.
15. Install NW80 centering ring, P/N 810008, and NW80 LF to NW40 KF reducing tee, P/N 824043, to the electropneumatic gate valve, P/N 307004, using 8 single claw clamps, P/N 801000. Net torque is 7 to 10 ft-lbs per manufacturer's recommendation. Running/locking should be 7.5-80 in-lbs. Install the bolts in a crisscross pattern to ensure even compression of the O-Rings.
16. Position the vacuum pump system next to OTF, SEG36144341-301.
17. Connect the NW80 LF to DN160 CF conical adapter, P/N MSPB1286, to the NW80 LF to NW40 KF reducing tee, P/N 824043, using a NW80 centering ring, P/N 810008, and 8 double claw clamps, P/N 802000. Install claw clamps per manufacturer's instructions. Net torque is 7 to 10 ft-lbs per manufacturer's recommendation. Running/locking should be 7.5-80 in-lbs. Install the bolts in a crisscross pattern to insure even compression of the O-Rings.
18. Support the vacuum hardware if needed to prevent damage to the OTF.
19. Install PR35 Penningvac Sensor, P/N 157 51, to an open port on the NW80 LF to NW40 KF reducing cross, P/N MSPB1260, using one NW40 centering ring, P/N 71002, and one NW40 hinged clamp, P/N 701002. Tighten wing

- nut until there is metal contact between the centering ring and the mating surface
20. Connect the CM31 Combivac vacuum gauge, P/N 157 89, to the PR35 Penningvac sensor, P/N 157 51, with the 5-meter Penningvac cable, P/N 162 88.
  21. Connect air supply and electric cord to the gate valve. Air supplied to valve needs to be cleaned with a filter of 40 microns capability.
  22. Seal all unused NW40 ports with a NW40 centering ring, P/N 710002; NW40 blanking flange, P/N 712002; and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.



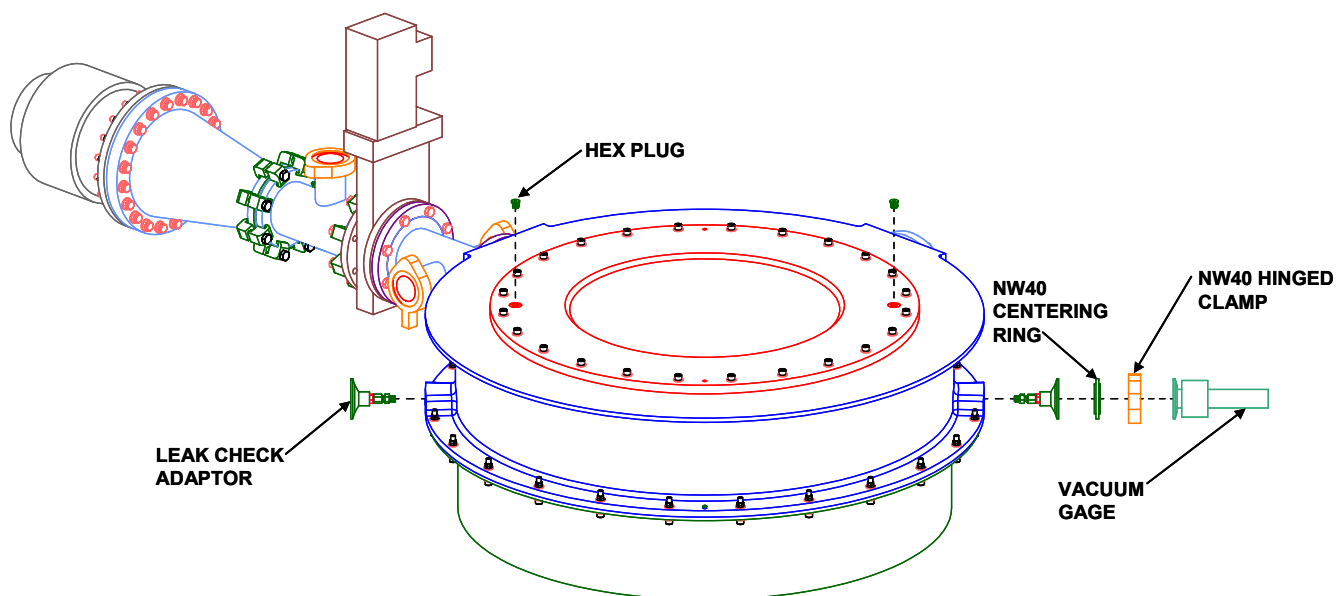
## **Appendix E: OTF Conical Flange External O-Ring Leak Check Setup Procedure**

1. Remove the hollow hex plugs, P/N 2 HP5ON SS V0894, from the Conical Flange Simulator, SDG36144342-001.
2. Install Leak Check Adaptor, P/N SEG36144347-301 to both test ports on the Conical Flange Simulator, SDG36144342-001. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw adaptor into female port to the finger tight position. Torque adapter 6-7 ft-lbs from finger tight.
3. Attach flex hose, P/N KLB01503600, to the leak check adaptor, SEG36144347-301, and the NW40 to NW25 adapter, P/N KRS2540S, with NW40 centering rings, P/N 710002, and NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
4. Attach the NW40 to NW25 adapter, P/N KRS2540S, to the helium leak detector with NW25 centering rings and NW25 hinged clamps. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
5. Install hollow hex plug, P/N 2 HP5ON SS V0894, on the test ports of the Support Ring Simulator Assembly, SEG36144344-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw hex plug into female port to the finger tight position. Torque hex plug 30-33 in-lbs from finger tight.
6. Attach the PR35 PenningVac sensor, P/N 157 51, to the other leak check adaptor, SEG36144347-301, with NW40 centering rings, P/N 710002, and NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
7. Bag the interface between the Conical Flange Simulator, SDG36144342-001, and the Support Ring Simulator assembly, SEG36144343-301, with plastic bags.
8. Attach the helium source to the plastic bags
9. Seal leakage areas of the plastic bag with duct tape to minimize helium leaks.



## Appendix F: OTF Outer Cylinder External O-Ring Leak Check Setup Procedure

1. Remove the hollow hex plugs, P/N 2 HP50N SS V0894, from the Support Ring Simulator Assembly, SEG36144343-301.
2. Install Leak Check Adaptor, P/N SEG36144347-301 to both test ports on the Support Ring Simulator Assembly, SEG36144343-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw adaptor into female port to the finger tight position. Torque adapter 6-7 ft-lbs from finger tight.
3. Attach flex hose, P/N KLB01503600, to the leak check adaptor, SEG36144347-301, and the NW40 to NW25 adapter, P/N KRS2540S, with NW40 centering rings, P/N 710002, and NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
4. Attach the NW40 to NW25 adapter, P/N KRS2540S, to the helium leak detector with NW25 centering rings and NW25 hinged clamps. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
5. Install hollow hex plug, P/N 2 HP50N SS V0894, on the test ports of the Conical Flange Simulator, SEG36144343-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw hex plug into female port to the finger tight position. Torque hex plug 30-33 in-lbs from finger tight.
6. Attach the PR35 PenningVac sensor, P/N 157 51, to the other leak check adaptor, SEG36144347-301, with NW40 centering rings, P/N 710002, and NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
7. Bag the interface between the Conical Flange Simulator, SDG36144342-001, and the Support Ring Simulator assembly, SEG36144343-301, with plastic bags.
8. Attach the helium source to the plastic bags
9. Seal leakage areas of the plastic bag with duct tape to minimize helium leaks.

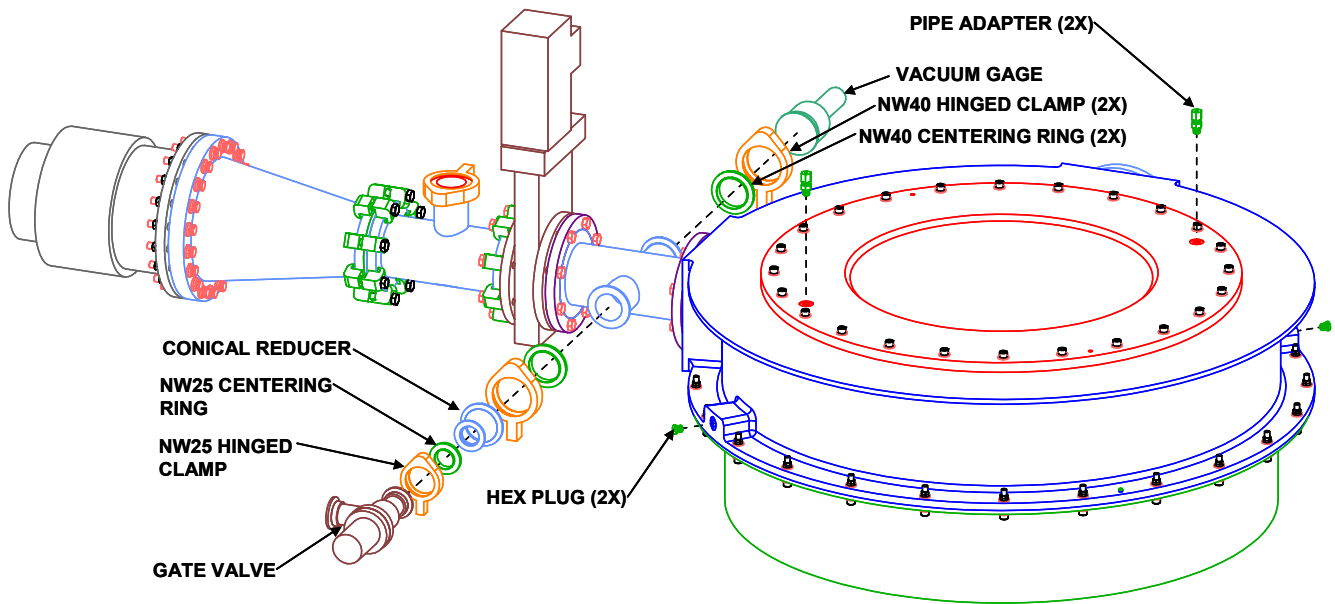


## **Appendix G: OTF Conical Flange Internal O-Ring Leak Check Setup Procedure**

1. Remove the PR35 Penningvac vacuum gauge, P/N 157 89, the flex hose, and the leak check adaptor, P/N SEG36144347-301, from the OTF.
2. Remove NW40 blank flanges, P/N 712002, from both port of the NW80 LF to NW40 KF reducing cross, P/N MSPB1260. Install the PR35 Penningvac vacuum gauge to an open port with a NW40 centering rings, P/N 710002, and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
3. Install the NW40 KF to NW25 KF conical reducer, P/N KRC2540S to the open NW40 port on the NW80 to NW40 KF reducing cross, P/N MSPB1260 with a NW40 centering rings, P/N 710002 and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
4. Install the NW25 gate valve, P/N 311073, to the NW40 KF to NW25 KF conical reducer, P/N KRC2540S with a NW40 centering ring, P/N 710002 and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
5. Connect air supply and electric cord to the NW 25 gate valve, P/N 311073. Air supplied to valve needs to be cleaned with a filter of 40 microns capability.
6. Connect the He leak detector to the NW 25 gate valve, P/N 311073, with NW25 centering ring and NW 25 hinged clamp. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
7. Install hollow hex plugs, P/N 2 HP5ON SS V0894, to the test ports on the Support Ring Simulator assembly, SDG36144343-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw plug into female port to the finger tight position. Torque hollow hex plug to 30-33 in-lbs from finger tight.
8. Remove both hollow hex plugs, P/N 2 HP5ON SS V0894, from the Conical Flange Simulator, SDG36144342-001.
9. Install male connectors, P/N SS-200-1-2ST, to the two test ports on the Conical Flange Simulator, SDG36144342-001. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw connector into female port to the finger tight position. Torque connectors to 6-7 ft-lbs from finger tight position.
10. Connect the helium source to the male connector, P/N SS-200-1-2ST which has a Swagelok fitting for a 1/8 OD pipe.
11. Insert the tubing into the Swagelok tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.
12. Before tightening the Swagelok nut, scribe the nut at the 6 o'clock position.
13. Hold the fitting body steady with a backup wrench and tighten the nut 1 ¼ turns. Watch the scribe mark, make one complete revolution and continue to the 9 o'clock position.



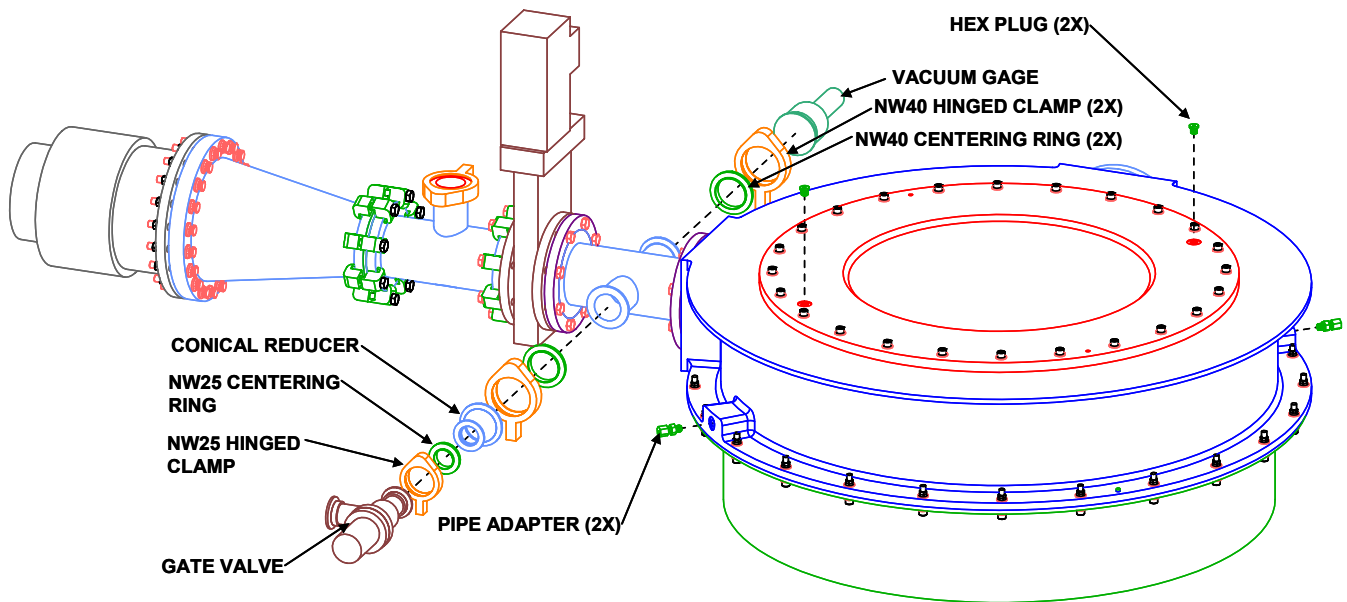
14. By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When the nut is tightened 1 ¼ turns to the 9 o'clock position, you can easily see that the fitting has properly tightened.
15. Connect another pipe to the other male connector, P/N SS-200-1-2ST, which has a Swagelok fitting for a 1/8 OD pipe. Install tubing per steps 11-14. Direct the other end of the pipe away from test area to prevent helium buildup.



## **Appendix H: OTF Outer Cylinder Internal O-Ring Leak Check Setup Procedure**

1. Remove the PR35 Penningvac vacuum gauge, P/N 157 89, the flex hose, and the leak check adaptor, P/N SEG36144347-301, from the OTF.
2. Remove NW40 blank flanges, P/N 712002, from both port of the NW80 LF to NW40 KF reducing cross, P/N MSPB1260. Install the PR35 Penningvac vacuum gauge to an open port with a NW40 centering rings, P/N 710002, and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
3. Install the NW40 KF to NW25 KF conical reducer, P/N KRC2540S to the open NW40 port on the NW80 to NW40 KF reducing cross, P/N MSPB1260 with a NW40 centering rings, P/N 710002 and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
4. Install the NW25 gate valve, P/N 311073, to the NW40 KF to NW25 KF conical reducer, P/N KRC2540S with a NW40 centering ring, P/N 710002 and a NW40 hinged clamps, P/N 701002. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
5. Connect air supply and electric cord to the NW 25 gate valve, P/N 311073. Air supplied to valve needs to be cleaned with a filter of 40 microns capability.
6. Connect the He leak detector to the NW 25 gate valve, P/N 311073, with NW25 centering ring and NW 25 hinged clamp. Tighten wing nut until there is metal contact between the centering ring and the mating surface.
7. Install hollow hex plugs, P/N 2 HP5ON SS V0894, to the test ports on the Conical Flange Simulator, SDG36144342-001. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw plug into female port to the finger tight position. Torque hollow hex plug to 30-33 in-lbs from finger tight.
8. Remove both hollow hex plugs, P/N 2 HP5ON SS V0894, from the Support Ring Simulator assembly, SEG36144343-301.
9. Install male connectors, P/N SS-200-1-2ST, to the two test ports on the Support Ring Simulator assembly, SEG36144343-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw connector into female port to the finger tight position. Torque connectors to 6-7 ft-lbs from finger tight position.
10. Connect the helium source to the male connector, P/N SS-200-1-2ST which has a Swagelok fitting for a 1/8 OD pipe.
11. Insert the tubing into the Swagelok tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.
12. Before tightening the Swagelok nut, scribe the nut at the 6 o'clock position.
13. Hold the fitting body steady with a backup wrench and tighten the nut 1 ¼ turns. Watch the scribe mark, make one complete revolution and continue to the 9 o'clock position.

14. By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When the nut is tightened 1 ¼ turns to the 9 o'clock position, you can easily see that the fitting has properly tightened.
15. Connect another pipe to the other male connector, P/N SS-200-1-2ST, which has a Swagelok fitting for a 1/8 OD pipe. Install tubing per steps 11-14. Direct the other end of the pipe away from test area to prevent helium buildup.



## **Appendix I: OTF System Leak Check Setup Procedure**

1. Install hollow hex plugs, P/N 2 HP50N SS V0894, into all of the test ports on the OTF, SEG36144341-301. Inspect NPT port and nipple to ensure that threads are free of nicks, burrs, and dirt. Screw plug into female port to the finger tight position. Torque hollow hex plug to 30-33 in-lbs from finger tight.
2. Bag the entire article with plastic bags.
3. Attach the helium source to the plastic bags
4. Seal leakage areas of the plastic bag with duct tape to minimize helium leaks.

## Appendix J: Vacuum Pull Procedure

1. The test area must be cleared of unnecessary personnel.
2. Zero strain and deflection gages.
3. Begin recording strain and deflection data.
4. Turn on the pneumatic pump to open the gate valve.
5. Turn on the CM32 Combivac vacuum gauge.
6. Turn on the roughing pump and the turbopump to pull the volume to  $1 \times 10^{-6}$  torr.
7. When the volume reaches  $1 \times 10^{-6}$  torr ( $1.32 \times 10^{-9}$  atm,  $1.93 \times 10^{-8}$  psi) turn off the turbo pump and the roughing pump. Open the vent valve on the turbopump. Repressurize the volume unless otherwise specified by the test engineer.

## Appendix K: External Leak Check Procedure

1. The test area must be cleared of unnecessary personnel.
2. Turn on the CM32 Combivac vacuum gauge.
3. Turn on the He Leak detector to pull the leak check groove to  $1 \times 10^{-6}$  torr.
4. Turn on the helium leak detector function when the vacuum pressure reaches  $1 \times 10^{-6}$  torr.
5. Fill plastic bags with 100% helium gas and continue flow of helium into the bag to maintain a slight positive pressure above ambient.
6. Monitor the leak rate for three minutes or until the rate has stabilized to within a 10 percent change over any ten-minute period, whichever is larger. The helium permeation rate should not rise above  $5 \times 10^{-7}$  std. cc He/s. The time involved can be changed as required by the Test Lead or the Test Engineer.
7. Record and print data
8. Turn off the helium leak detector, turbo pump, and the roughing pump at the conclusion of the test and repressurize the OTF leak check groove volume at the conclusion of the test.
9. Flush helium from leak check groove by flooding the grooves with dry nitrogen or air. Disconnect piping for helium Supply.

## Appendix L: Internal Leak Check Procedure

1. The test area must be cleared of unnecessary personnel.
2. Turn on the pneumatic pump to open the gate valve.
3. Turn on the CM32 Combivac vacuum gauge.
4. Turn on the roughing pump and the turbopump to pull the OTF volume to  $1 \times 10^{-6}$  torr.
5. Isolate the OTF volume from the turbopump when the pressure reaches  $1 \times 10^{-6}$  torr. Turn off the turbopump and roughing pump and repressurize the pump volume.
6. Turn on the helium leak detector after isolating the OTF volume.
7. Flow 100% helium gas into leak check groove.
8. Monitor the leak rate for three minutes or until the rate has stabilized to within a 10 percent change over any ten-minute period, whichever is larger. The helium permeation rate should not rise above  $5 \times 10^{-7}$  std. cc He/s. The time involved can be changed as required by the Test Lead or the Test Engineer.
9. Record and print data
10. Turn off helium leak detector at the conclusion of the test and repressurize the OTF volume at the conclusion of the test.
11. Flush helium from leak check groove by flooding the grooves with dry nitrogen or air. Disconnect piping for helium supply.

## Appendix M: System Leak Check Procedure

1. The test area must be cleared of unnecessary personnel.
2. Turn on the pneumatic pump to open the gate valve.
3. Turn on the CM32 Combivac vacuum gauge.
4. Turn on the roughing pump and the turbopump to pull the OTF volume to  $1 \times 10^{-6}$  torr.
5. Isolate the OTF volume from the turbopump when the pressure reaches  $1 \times 10^{-6}$  torr by turning off the pneumatic pump for the gate valve.
6. Turn off the turbo pump and the roughing pump. Open the vent valve on the turbopump.
7. Turn on the helium leak detector after isolating the OTF volume.
8. Fill plastic bags with 100% helium gas and continue flow of helium into the bag to maintain a slight positive pressure above ambient.
9. Monitor the leak rate for three minutes or until the rate has stabilized to within a 10 percent change over any ten-minute period, whichever is larger. The helium permeation rate should not rise above  $5 \times 10^{-7}$  std. cc He/s. The time involved can be changed as required by the Test Lead or the Test Engineer.
10. Re-pressurize the volume by opening the vent valve on the helium leak detector at the conclusion of the test.
11. Flush helium from leak check groove by flooding the grooves with dry nitrogen or air.



## Appendix N: Long Term Leak Rate Procedure

1. The test area must be cleared of unnecessary personnel.
2. Turn on the pneumatic pump to open the gate valve.
3. Turn on the CM32 Combivac vacuum gauge.
4. Turn on the roughing pump and the turbopump to pull the OTF volume to  $1 \times 10^{-6}$  torr.
5. When the volume reaches  $1 \times 10^{-6}$  torr ( $1.32 \times 10^{-9}$  atm,  $1.93 \times 10^{-8}$  psi) turn off the air supply to the isolation the OTF volume.
6. Turn off the turbo pump and the roughing pump. Open the vent valve on the turbopump.
7. Disconnect the turbopump and the roughing pump from the OTF, P/N SEG36144341-301.
8. Personnel from the AMS-02 project will check the pressure readout at predetermined intervals and record the vacuum values. Continue to record the vacuum level for a minimum of six months. The AMS project will determine at that time whether or not to continue the test.
9. At the conclusion of the test, reconnect the turbopump and the roughing pump and turn on the turbopump and the roughing pump to equalize the pressures on both side of the gate valve. Turn on the air supply to open the gate valve when the pressures are **equal** on both sides.
10. Re-pressurize the entire test article by opening the vent valve on the turbopump at the conclusion of the test.

## **Appendix O: Procedure for Swagelok Tube Fittings**

1. Insert the tubing into the Swagelok tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.
2. Before tightening the Swagelok nut, scribe the nut at the 6 o'clock position.
3. Hold the fitting body steady with a backup wrench and tighten the nut  $1 \frac{1}{4}$  turns. Watch the scribe mark, make one complete revolution and continue to the 9 o'clock position.
4. By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When the nut is tightened  $1 \frac{1}{4}$  turns to the 9 o'clock position, you can easily see that the fitting has properly tightened.

**Appendix P: Vacuum Gauge Measurement Uncertainty**

<b>Range</b>	<b>Uncertainty</b>
$10^{-8}$ to $10^{-4}$ mbar/Torr	$\pm 30\%$ of the measured value
$10^{-3}$ to $10^{-2}$ mbar/Torr	$\pm 20\%$ of the measured value
$10^{-2}$ to $10^2$ mbar/Torr	$\leq 15\%$ of the measure value